5G CityView Innovation Accelerator

by Harvard TECH at Dublin

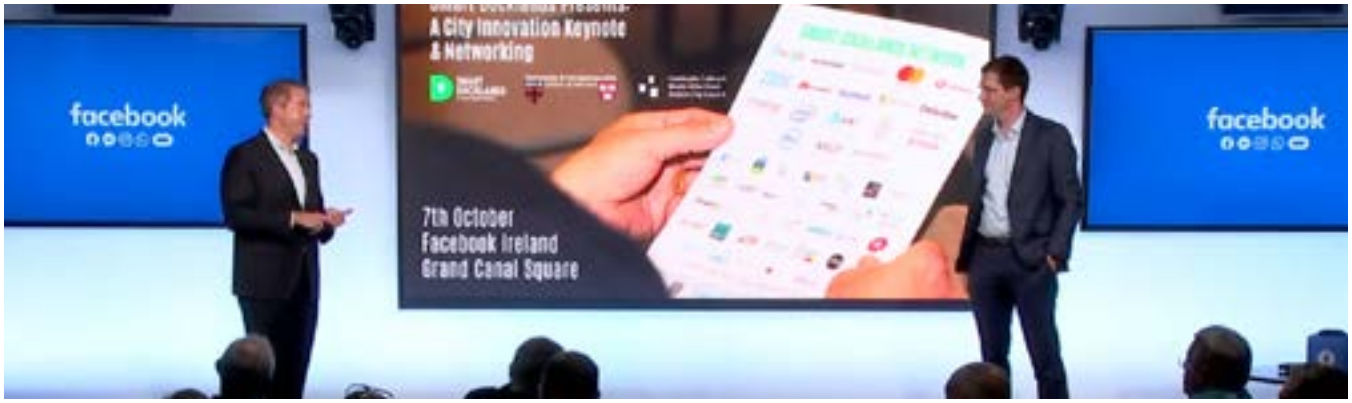
www.cityinnovatorsforum.com

5G CityView Innovation Accelerator – Dublin 2019

5G is truly upon us and rolling out this year in many areas of the globe. The technology is constantly evolving as are the policies and impact on governments and citizens. At the 5G CityView Innovation Accelerator, convened by the Technology and Entrepreneurship Center at Harvard and hosted by Dublin City Council, we heard from global experts on 5G including leading academics, industry experts and cities who have or will be rolling out 5G pilots and platforms.

This whitepaper summarizes the learning that occurred over the two-day accelerator, including why 5G matters and the opportunities and challenges that cities face.

Watch the opening keynote by Dr. David S. Ricketts at http://bit.ly/Dublin2019-Ricketts



Why 5G Matters

5G is the next evolution of mobile technology after 4G LTE. It is designed to bring faster speeds, higher capacity, lower latency, efficiency, reliability, and an ability to handle a huge number of connections.

The global economy is at a pivotal point as we see a move towards an increasingly connected society driven by the Internet of Things (IoT), Artificial Intelligence (AI), and Big Data. The pace of adoption of these types of technologies will become the basis for long-term national economic growth. The application and impact of these emerging technologies will be underpinned by connectivity and, in particular, the type of connectivity that 5G offers.

Economists estimate the global economic impact of 5G in new goods and services will reach $12 trillion by 2035 as 5G moves mobile technology from connecting people to people and information, towards connecting people to everything. 5G could make possible the connection and interaction of billions of devices of almost any kind and collection of data from those devices in near real-time.

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The Road to 5G

About every ten years, the world is presented with new technology for communication. With each upgrade came new applications: "0G" featured analog and 1G took analog wireless. Next came 2G with digital voice, 3G had a few apps with mobile data, and 4G has countless apps with broadband data.

When you look at the most popular apps developed over the years, many of them have nothing to do with making a phone call, observed Professor Luiz DaSilva, Director of CONNECT at Trinity College Dublin.

Instead, these apps were created to serve a purpose in a consumer's everyday life from dating to shopping and getting around town. Now smartphone users are hailing rides, reserving accommodations, ordering dinner, and looking for a date, just to name a few. None of these apps would have been possible before 4G.

With the advent of 5G, the future of app development will be largely determined by other technology in our lives, predicted DaSilva.

We are already seeing this with the development of autonomous vehicles, AR/VR, manufacturing, and haptic feedback with low delay.

Apps will correspond with the latest technologies, DaSilva added, including those we haven't thought of yet.

"The researchers that created the first generation of wireless networks couldn't have imagined most of these applications," said DaSilva. "To the same extent, we are designing for what we don't know is yet to come. So we need the design to accommodate all that innovation that comes from other people."

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What Exactly is 5G?

With all this talk about the potential of 5G, experts have a difficult time explaining what it actually is. We all know about WiFi, but what you may not know is that the name doesn't actually stand for anything—it was a marketing term that was invented. Using a play on the term Hi-Fi, marketers were able to use a word to represent something new. This allowed experts to talk about it in their marketing, painting a picture that consumers and manufacturers could easily understand. It was a brand of what was to come.

The same is true about 5G in that it's not a technically defined term, explained David S. Ricketts, Innovation Fellow at Harvard TECH. While you could say that the "G" stands for "generation," but that still doesn't tell us what it is. In fact, the term 5G simply refers to all the cellular features and standards released until 6G comes along around 2030.

The telecom industry uses a similar strategy as the phone and vehicle manufacturers—when the market is saturated with the product that still works consumers will only upgrade for the promise of new features.

3GPP Standards: Sorting Reality from Marketing

When we set marketing aside for a moment, the only real thing about 5G is a set of standards documented by The 3rd Generation Partnership Project (3GPP) (https://www.3gpp.org/). This online body publishes standards for cellphones and documents the tangible features that set them apart.

Each generation of cellular evolution typically includes between four and five releases before the next iteration. When we talk about 5G and its features, the reason experts don't know what the future holds is because releases 17 and 18 haven't been written yet.

Source: ***Adapted by D. S. Ricketts, from original by Michael Steer***

As we reflect on the evolution of the cell phone, real change didn't happen until the 3G network opened possibilities for innovation.

"3G is what made smartphones," said Ricketts. "It wasn't the iPhone, it was the third-generation network. When we talk about going to this next generation, what we're really doing is enabling the next smartphone in the sense of technology we've never envisioned before."

5G Features

Now that we know what's real, you should know that 5G is made up of 4G features (but more of them!) as well as some new features including:

Carrier aggregation (4G+)

Carrier aggregation allows 4G users to speed up connection speeds by accessing unused cell connections nearby—up to five simultaneously. This number increases up to 32 with 5G, allowing dramatically increased data rates.

Orthogonal Frequency Division Multiplexing (OFDM) (4G)

OFDM leverages and mitigates the effect of bouncing signals. As data signals leave the tower, they interact with objects in their paths such as buildings and trees. This causes signals to reach the receiver multiple times at different times and strengths. OFDM, in effect, stretches transmissions out so that the path delay is a smaller fraction of the signal, thus making differences in path delay less important. This technology will continue into 5G.

Massive MIMO (4G+)

Modern cellular devices contain multiple antennae. By using advanced mathematics and leveraging the multiple paths signals can take in cities, engineers can actually send multiple sets of different data from each antenna, thus significantly increasing throughput. This is referred to as Multiple Input, Multiple Output (MIMO). This technique is most beneficial in cities,due to the need for multiple, independent paths from each antenna. With 5G, the number of antennae can be increased significantly as the wavelength, and thus antenna size, reduces, allowing for what is referred to as Massive MIMO. Massive MIMO is simply MIMO with a massive amount of antennas.

Relays and Mesh Networks (New)

5G introduces mesh networks where small nodes act as intermediaries between towers and receivers, navigating around obstacles that would normally slow down or weaken a signal. Other 5G phones will also act as relays, enabling even better reception. Thus we will no longer rely on just the cell towers but also smaller relay points, or cells. These are referred to as nano-, pico- and femtocells. The names simply draw an analogy to the definition of those terms as being different (and very small) sizes.

Lower Latency (New)

The human voice needs less than 150 ms of latency to be understood, so 4G was set up to be less than that— around 80 ms. 5G will take that down to about 1 ms, which is 1/100th of a second. While the difference won't be noticeable for things like voice calling and video streaming, the real difference will be felt for things that need to be controlled in real-time, such as IoT. You could literally do surgery in Hong Kong from Dublin over a 5G connection. For example, 4G MIMO is up to 4x4 (4 transmit antenna and 4 receive antenna), 5G Massive MIMO is up to 64x64 (64 transmit and 64 receive antennas) increasing capacity dramatically.

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- Dr David Ricketts

MM-wave (New)

Current cell phones communicate at 1GHz, which is one nanosecond period,or 30 cm wavelength. 5G will utilize more frequencies such as 30GHz, which is only 0.033 nanosecond period, or 1 cm wavelength. The shorter wavelength allows many more antennas to be put into a small footprint. This allows Massive MIMO.

In addition, data rates scale with the carrier frequency, such that (approximately) a 30 GHz carrier can send 30 times as much data as a 1 GHz carrier.

Millimeter waves can't pass through buildings and tend to be absorbed by trees and rain, however, so the solution becomes small cell networks that act as relays.

Beamforming (New)

An array of antennae emitting millimeter waves can be focused in a specific direction by adjusting the phase. Beamformers change the way antennae speak to a receiver in real-time, such as adjusting for movement as a person moves through a city. Thanks to the shorter wavelength of mm-waves, multi-antenna beamforming can be built in small footprints, thus allowing beamforming in 5G. By focusing spatially on a particular receiver instead of scanning other receivers nearby, other channels remain open for use, reducing congestion.

5G: Opportunities and Challenges for Cities

Innovation for a Better Future

When talking with cities, don't just talk about all the data, advised David Graham, Chief Innovation Officer of the City of Carlsbad, CA. Rather, outline all the insights, value, and communication that comes with 5G such as:

- Civic engagement - passive and active
- Mobility - connected vehicles, transportation management
- Sustainability - energy management, climate adaptation
- Public Safety - situational awareness, mission analytics
- Connectivity - wireless high-speed everything, mobile connectivity versus hard infrastructure

Potential Use Case: The Rose Parade

Since 1890, visitors have flocked to Pasadena, California, to enjoy the annual Rose Parade. A city of 138,000 swells to 700,000 for a one-day event that is viewed by 76 million worldwide. Until just a few years ago, the Rose Parade was managed by individuals with paper maps and walkie-talkies.

Pasadena has now moved to Integrated Situational Awareness that uses technology to coordinate data concerning all facets of the event. Pre-event drones are deployed to capture imagery, survey-grade GPS precision is used for assets of interest, and NOAA weather data and forecasting keep the team ahead of environmental changes. All of this and more are managed with real-time data fed to the command center using multiple networks.

The reliability, ubiquity, low latency, and high speeds of a 5G network could transform how Pasadena oversees its world-famous parade from planning to real-time execution.

Source: ***David Graham***

Navigating Obstacles

While there is a lot of hype or expectations around the possibilities of 5G, it's clear that the benefits of 4G are still being realized. Limitations on coverage are still apparent in cities across the globe. There is also the question of how 5G deployments will play out geographically as the technology is more challenging to deploy in high levels of concentration. Even though 4G LTE rollouts started as early as seven years ago, they are still not nearly as ubiquitous in terms of coverage as 2G and 3G.

Other challenges facing 5G implementation include regulations, misaligned business cases, getting to adoption, and the community.

Real Estate

"Cities are complicated, and now we have this incredible technology that can affect both what we do in cities but also affect the way that we live," said Graham. "In many cases around the world, we're not set up well for the massive amount of investment of infrastructure technology that we see with 5G."

5G requires a large network of smaller relays, which creates challenges for telcos because they don't own the buildings, lamp posts, etc. These companies now have to work alongside city municipal governments, Graham explained.

"When you look at the challenges and barriers to entry for deploying small cells, it's largely location, power, and backhaul,"

- Paul Coffey, Dense Air

One solution to the lack of space is to share resources, noted Paul Coffey, Head of Strategy at Dense Air, adding that to reduce costs, a number of mobile operators have already begun sharing passive infrastructures like antennas, towers, and power. Others are selling their macrocells altogether.

"When you look at the challenges and barriers to entry for deploying small cells, it's largely location, power, and backhaul," said Coffey.

With only so many street lights available, Dense Air deploys small cells on a dedicated licensed spectrum that are host neutral, meaning that any carrier or private network can use them simultaneously. The company also offers indoor solutions in consideration of 5G's non-penetrating MM-waves.

"By dropping a small cell in the right location, you're not only relieving congestion or adding capacity or coverage, but you're also serving a benefit to the underlying macrocell," Coffey explained, as macrocells do not have to work as hard to transmit data to an end-user

Community Concerns

The City of Carlsbad receives daily emails expressing concerns about potential hazards, said Graham. These include accusations that the new 5G antennae are "killing their cats," even though 5G hasn't been deployed yet. Protesters also claim that millimeter waves are dangerous to human health.

"This really requires an alignment of priorities if you're going to be able to manage the hysteria that we see about a technology," advised Graham.

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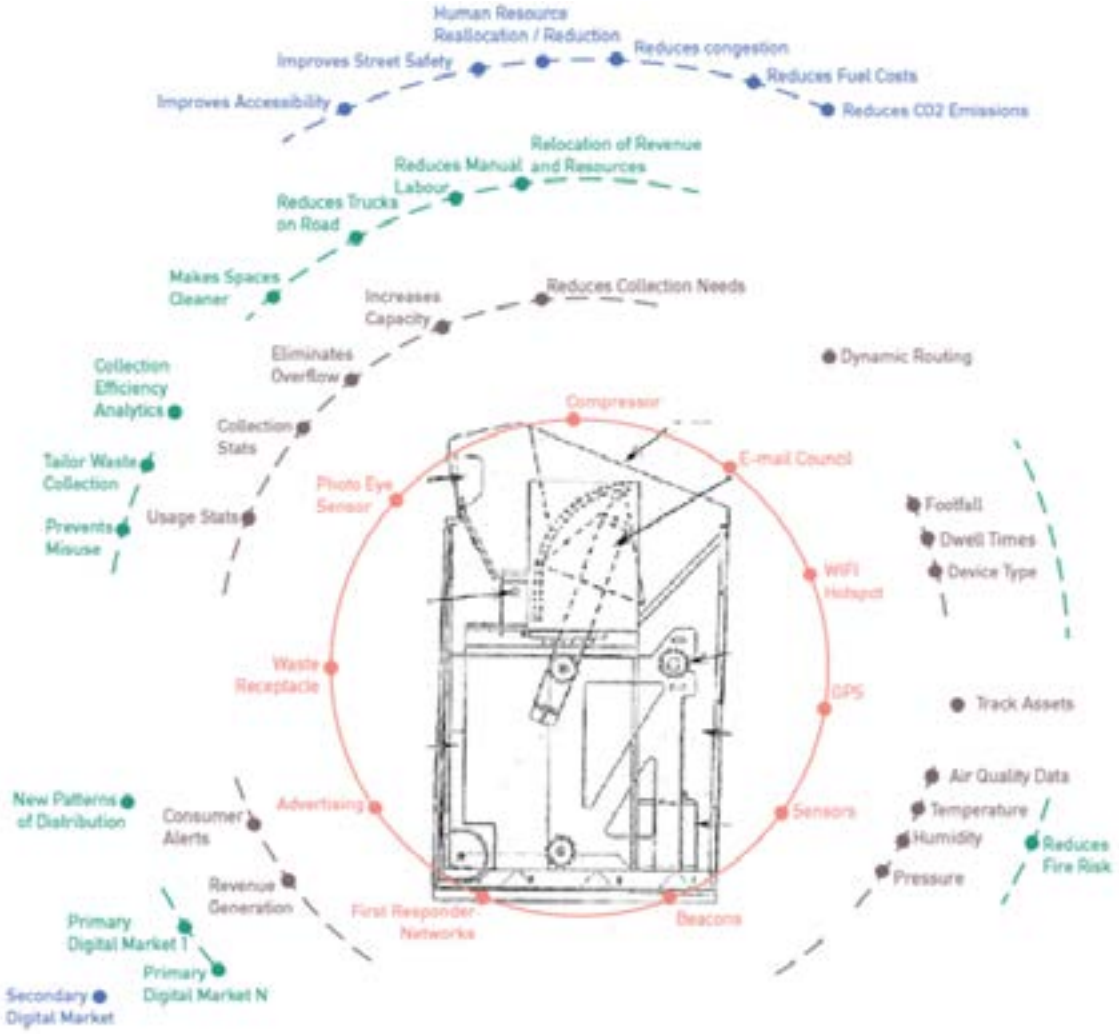
Smart Cities: Who's Shaping Who?

"Do we fit the city to 5G, or do we fit 5G to the city?" submitted Linda Doyle, Professor of Engineering & the Arts and Dean of Research at Trinity College Dublin.

Smart objects turn everyday items into much more than its sole purpose. For example, a smart bin in New York City is no longer just a receptacle for waste—it is a Wi-Fi hotspot, GPS, beacon, first responder network, advertisement, and more. As you move outward from its main objective, the smart bin takes on even more identities, such as a source of revenue, reducer of traffic congestion, and a labor saver.

Once the sole responsibility of the department of sanitation, smart bins are now overseen by multiple departments of the mayor's office, private companies, and business innovation districts.



A smart bin and its multiple identities. Source: **Linda Doyle, Fiona McDermott**

A new IoT system means that trash will be collected based on real-time data from smart bins, changing routines that go back decades and even further. In fact, for a decentralized and heavily unionized municipal waste system department like DSNY, labor contracts and trade union agreements are based on these old collection routines.

While smart objects offer a myriad of benefits, innovation leaders must recognize that traditional objects serve multiple purposes as well that cannot be as easily replaced, ranging from neighborhood routines to city culture. It may become necessary, Doyle added, to ask if it's right to have 5G change a city and not the other way around.

In their 1968 book Learning from Las Vegas, architects Denise Scott Brown and Robert Venturi observed that buildings and signs became larger and more symbolic in areas where cars were driving past at high speeds.

Las Vegas and countless other cities have evolved its infrastructure to accommodate traffic in this way. 5G, Doyle postulates, is the new fast-moving car. While cities consider the rollout of a 5G network, she said, leaders should consider the best use of assets for the benefit of citizens, and not just the most convenient rollout.

5G in Action

Why Local Authorities Must Get Involved

Local authorities, by virtue of their sheer operational influence and ownership of multiple assets in key locations, will play an instrumental role in 5G deployment. The criticality of collaboration and engagement between local authorities and stakeholders, such as mobile operators, will be elevated with 5G. This is relative to prior mobile network technologies, taking into consideration the new set of deployment challenges and emerging economic opportunities.

In order to carefully manage urban disruption such as road openings, local authorities will need to work closely with mobile operators during the deployment phase of 5G in cities and towns, minimizing the impact on traffic flow and the mobility of citizens.

There is a strong consensus that local authorities and other state bodies need to be more proactive about how they can leverage their assets to support 5G. This needs to go beyond the current situation—dealing with ad-hoc requests—to a more structured model in which the local authority facilitates access to assets in an open and transparent manner for operators.

It is clear in many cities across the world that the combined time and cost of applying for new power connections (to deploy small cells, IoT equipment, etc.) renders it nearly impossible to justify deployments at scale.

The challenge associated with power extends beyond unmetered supply, however, and also includes physical accessibility issues with regard to the installation of mini-pillars in an already congested street environment.

There are a number of critical factors that have to be addressed:

1. Faster and more streamlined access to appropriate city assets (poles, traffic columns, buildings, street furniture)
   a. Review of the current planning approach and issuing of licenses to consider 5G and small cell deployments at scale
   b. Assessment of the condition of assets and suitability of sharing as well as drafting appropriate service level agreements

2. Access to fiber / ducting
   a. Provision of access to LA owned ducting to reduce road openings
   b. Practicality of getting fiber to multiple sites in cities

3. Access to power and how to enable rapid deployment of small cells on existing powered assets
   a. Cost of connections and metering
   b. Use of unmetered supply
   c. Time to get a connection

Formulating a 5G Strategy

5G Deployment Models

Mobile Network Operator (MNO) Macrocell Upgrade

This is the current method of 5G rollout used in cities across the world, including Ireland, where mobile network operators upgrade current macrocell locations to 5G-ready equipment.

This has been the case with the rollout of 5G by Vodafone and EIR to date. Operators have indicated that this type of upgrade will likely suffice for their short term 5G network requirements (2-5 years).

However, some sectors maintain that MNO macrocell upgrades will not address the long term challenge of network densification. Alternative models will be required as small cells increasingly become part of operators' longer-term rollout plans, which include the following:

Neutral Host Model

A lot of discussion has emerged regarding the concept of a 'neutral host' network, which could help to accelerate 5G deployment and make it more economical to scale. The neutral host model involves the deployment of a single physical small cell that can be shared by multiple operators, particularly in a dense urban setting, such as those by DenseAir. This method is an alternative to multiple equipment installs which provides cities with aesthetic and operational challenges. This network would complement the existing infrastructure and have already been or are being deployed by mobile operators.

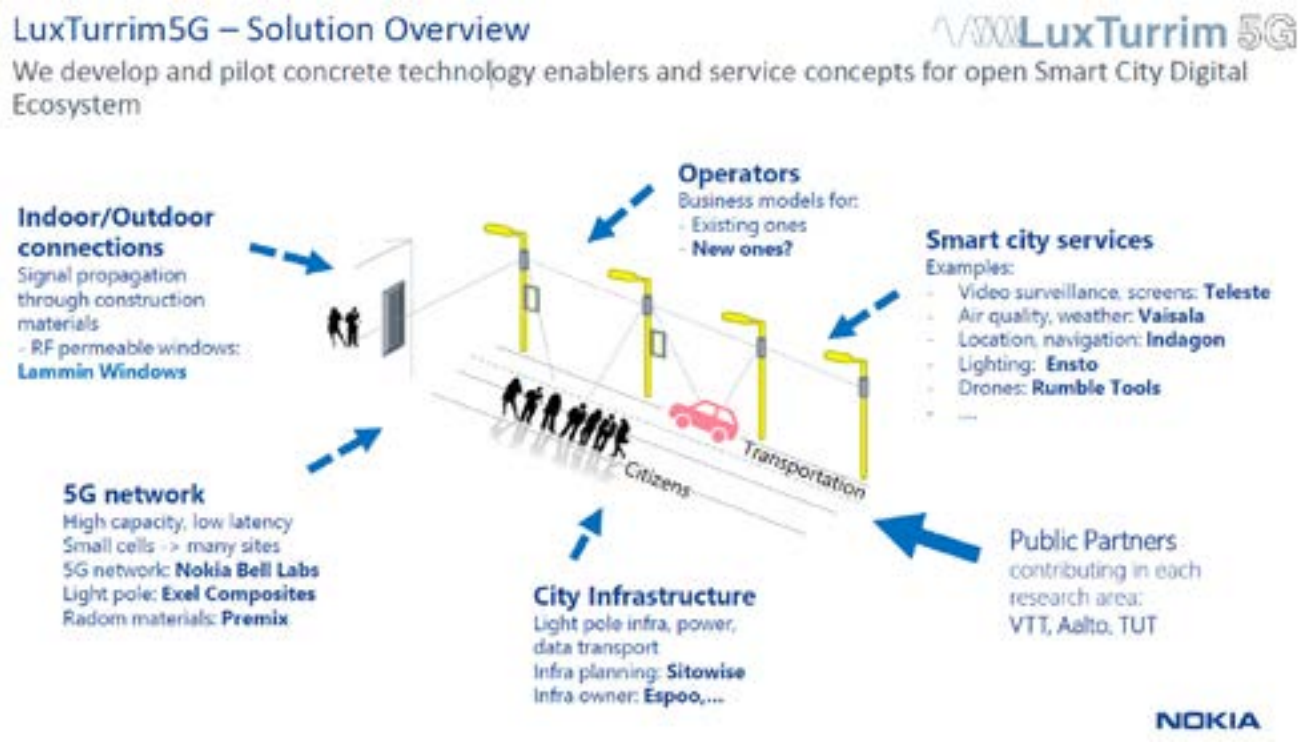
It should be highlighted that there are many flavors of Neutral Host. However, for the purposes of this paper, we define Neutral Host as when local authority works with one facilitating entity who manages one physical small cell on a city asset.

Within Neutral Host, the two main kinds to be aware of are:

1: Passive Neutral Host, a.k.a Multiple Operator Antennas in One Small Cell

This involves a one-piece enclosure deployed with multiple operators' equipment inside. This means the only thing the operators are sharing is the small cell and not the radio spectrum. Passive Neutral Hosting can be utilized by a single small cell while supporting multiple MNOs' frequency bands.

Nokia suggests looking at the city as a platform, made up of physical infrastructure, high-performance networking, multi-cloud storage, digital value platforms, and business applications with 5G connectivity as a key component of a wider ecosystem



A pilot program dubbed LuxTurrim5G was launched on the Nokia campus in Finland. A miniature smart city was created that implements multifunctional light poles. Around 23 different partners contribute to the projects' research.

2: Active Neutral Host, a.k.a Spectrum-based Sharing

This is where the provider has its own local radio resources (shared or dedicated) and network, hosting other MNOs & SPs as tenants. This means the sharing happens in the core radio rather than at the small cell on the street level.

This style of Neutral Host is currently being pioneered by Dense Air who exploring it in Ireland, Australia, New Zealand, Portugal and Belgium

The Shared Infrastructure Model

The shared infrastructure model allows access to one city asset for multiple small cells. Although the local authority may deal with one or multiple vendors, depending on the SLA, this model will still have multiple small cells on one city asset.

While this model creates additional real estate for small cell deployment, planners must remember that without collaborative city input, an array of "small" cells can turn into a loud, intrusive "frankenpole" very quickly, as illustrated by the following example:

*The above flyer was used to depict what proposed California Law AB 2788 would have allowed, compared to a more realistic and pragmatic approach. The bill was ultimately scrapped. (Source: **Omar Masry**)*

The Exclusive Concession Model

In the exclusive concession model, a period of exclusivity is granted by the local authority to a single concessionaire in order to incentivize investment in connectivity. In return for the granting of exclusivity, the concessionaire pays an upfront fee and, oftentimes, shares a portion of its revenues with the local authority. This has been used in many cities across the UK which has led to reduced competition and connectivity options for citizens in certain areas of cities.

Small Cell Deployment Business Models

While there are many variants in the operational models to deploy small cells, there are also several different business models being developed to facilitate the deployment of small cells in a fair and equitable manner. The most popular models currently emerging are:

- Special Purpose Vehicle (SPV) or Join Venture (JV) - The Local authority creates a legal entity with a small cell provider, usually a neutral host provider such as Dense Air, and this entity manages the operational roll-out of small cells. Typically the local authorities' contribution to this model is their assets and in some cases, they may provide additional funding.
- Concession Model - The local authority will consult the market and choose one third party entity, either a small cell provider or MNO, to grant access to their assets. This is often done on an exclusive basis, reducing the level of competition in cities. For example, Arqiva was awarded the concession contract with London borough Hammersmith & Fulham. The company will have exclusive rights to use street assets in the area including lampposts on which to install small cells for 5G.
- Some providers like BT, however, argue that concession models drive up costs and slow down the implementation of 4G and 5G in cities. In fact, the company has proposed the idea of ending its own exclusive agreements to encourage other local authorities and the wider industry to adopt an alternative open access model.
- Lease Agreements - This model, used in San Jose, where the Local authority grants multiple MNOs access to individuals assets on a lease basis.

Lease Agreements Use Case: San Jose, California

San Jose, California, is the 10th largest city in the U.S. It's geographically diverse and home to 1.2 million citizens. A "tale of two cities," San Jose hosts some of the wealthiest zip codes in the country but also some of the poorest neighborhoods in California. In fact, approximately 50,000 households can not afford internet access.

Dolan Beckel, Director of the Office of Civic Innovation and Digital Strategy at the San Jose City Manager's Office, was tasked with preparing for an explosion of connected devices and data.

Around 2017, San Jose was following a market-led model. With this type of model, San Jose relied on the telecom duopoly to make improvements to enhance their networks. Unfortunately, there was a lack of improvement to systems, especially in low-income neighborhoods, which caused this model to fail the needs of San Jose. With a lack of substantial competition, market-led cities like Los Angeles and San Diego were left to stagnate.

On the other side of the spectrum, governments like those in San Francisco and Chattanooga took on the full weight of a new fiber network and found it to be expensive, complex, and risky. In fact, San Francisco has since shelved its $2.5B Municipal Wireless project.

Beckel proposed that San Jose adopt a hybrid model that enters into private partnerships while cooperating with broadband providers to improve broadband connectivity. The city's priorities were economic development, digital inclusion, and smart cities and IoT.

"In cities, the most valuable piece of asset we have is our streetlight. Streetlights fit all the criteria for the installation of small cells with their height, density and power."

Dolan Beckel,
City of San Jose

	Government-led	Hybrid model	Market-led
	Chattanooga San Francisco (shelved plans)	New York City Seattle Charlotte Kansas City	Los Angeles San Diego San Jose (historically)
Summary	Cities building full fiber networks is expensive, complex, and risky **Too Risky**	Cities that welcome private investment with appropriate guidance are most successful **Just Right**	Cities with laissez faire broadband stagnate as cable-telecom duopolies **Too Ineffective**
Key Takeaways	• Seattle, Palo Alto and others have determined that city-led full fiber build-outs are not practical, after detailed assessments • Chattanooga's unique buildout included control by the utility and federal funds	• **Enter into value exchange agreements leveraging City Assets to incent investment, fund speed and predictability, and close the digital divide** • **Centralize broadband governance** • **Adopt balanced broadband friendly policies**	• Broadband speed and price cluster to the bottom of the peer set • No substantial competition in any market-led city

In June of 2018, San Jose made agreements with AT&T, Verizon, and Sprint. The result will be approximately $500 million in private sector infrastructure improvements, including 1,000 miles of fiber and 4,100 small cells, both 4G and 5G, installed throughout the city.

"In cities, the most valuable piece of asset we have is our street light," said Beckel, adding that San Jose owns all 67,000 of them. Street lights fit all the criteria for the installation of small cells with their height, density, and power.

Leasing this space funded the improvements necessary to meet telecom partners' goals of speed and predictability. To aid in the design of networks throughout the city, San Jose created a number of tools, including an online small cell site reservation portal.

Small Cell Site Reservation Portal

Cities should avoid creating unsightly "frankenpoles" that tack on equipment without consideration to aesthetics, advised Beckel. Light poles in San Jose hide the 4G antenna and use minimalistic design, even with 5G beamforming antennas added.

4G antenna in San Jose

5G antenna test site in San Jose

In general, any business model varies on the current conditions in the city; e.g., whether the city owns the lighting and traffic assets, whether the city owns fiber, does the city want to manage the deployment themselves or outsource to a third party etc.

Not all cities are alike - a point made by Verizon and AT&T while rejecting a proposal by FCC Commissioner Jessica Rosenworcel to use San Jose's approach to small cells as a template for similar deployments in other cities.

"The costs associated with some of these arrangements also are high, far exceeding the costs incurred by cities, and it would be a mistake to assume that they would be economical in many other locations," Verizon's Will Johnson wrote on the telecom company's public policy blog in March 2019.

It is expected in 2020 that more innovative models will emerge that will benefit Local authorities, MNOs, small cell operators, and all involved in the deployment of telecoms equipment. As the technology is relatively new, 2020 will be the first year cities engage the market on a wide-scale and we may see cities creating models for entities to manage all wired and wireless telecoms on their behalf.

Tech for Tourism 5G Use Case: Amsterdam

What drives 5G implementation in Europe? The same thing that drives many Europeans - football. That isn't the only reason, of course, but the UEFA European Football Championship 2020 was a great excuse to set a deadline for 5G implementation.

In 2016, The 5G Infrastructure Public Private Partnership (5G PPP) announced the testing and piloting of 5G initiatives across Europe, including Amsterdam - one of the 12 host cities for UEFA EURO 2020.

Burcu Kuzlac leads Amsterdam's 5G initiatives as a member of the city's innovation team. She explained that Amsterdam is focusing on public safety and emergency services as they relate to crowd control in and around the busy city centre.

In April of 2018, Amsterdam and its partners kpn, Nokia, and Johan Cruijiff Arena began testing three use cases: crowd control, body cameras, and 5G connectivity for citizens.

Cameras mounted outside the Amsterdam Arena track the direction of a crowd at the entrance according to established parameters, Kuzlac explained. Custom borders and alerts are created, then tracked by special software so that decisions can be made quickly about irregular or undesired behaviors.

Another use for 5G in and around the Amsterdam arena is live streaming via steward body cams. Kuzlac stressed the importance of real-time feeds and human interaction in the case of an emergency. For example, stewards were recently able to locate, monitor, and assist a patron with medical concerns using this technology.

The city is also developing a plan for 5G in the southeast Amsterdam region that hopes to address citizen pain points like parking as well as communication needs.

Connection Speeds Save Lives

5G Use Case:

Bristol, England

Last year, the West of England Combined Authority secured £5 million to trial a super fast 5G network at tourist destinations in Bristol and Bath. Working as a collective with their partners, City Council looked at improving safety around Bristol's Harbourside.

The former city-centre port is now a cultural hub where university students gather and party but sometimes with disastrous results.

Visitors and residents keep falling or jumping off of the harbor walls, Snell explained, and the swift currents carry them away. Emergency services estimate that on average, it costs £90,000 to mobilize a rescue operation. In addition, many victims drown because they are not rescued in time. In addition, the chances of survival drop significantly if emergency services do not know where a person hits the water within a one-metre radius.

Teenagers simply climb over the fences, and building a six-foot wall wasn't an option, Snell said. Instead, Bristol is Open deployed a series of hi-definition thermal imaging cameras.

GDPR prevents the use of HD cameras except in the case of an emergency, so Bristol used thermal imaging, as body heat is not private information. The camera searches for movement and determines when someone enters the water based on their body heat. From there, the situation becomes an emergency, and the privacy rules are overridden, allowing for the use of HD cameras.

"We could not have done this in 4G," said Snell. "We ran a comparison and tried to run it on 4G, but we needed the latency [of 5G]."

Julie Snell,
Bristol is Open

When the software detects a person in or near the water, decisions can be made quickly as to whether emergency services should be dispatched.

"We could not have done this in 4G," said Snell. "We ran a comparison and tried to run it on 4G, but we needed the latency [of 5G]."

Bristol is Open also uses the software for crowd detection and its command center for 5G Tourism Event Control—wirelessly connecting telephone, WiFi, camera visualization, crowd analysis, and marshal tracking for the Harbour Festival.

We saw four different deployment models illustrated during the 5G CityView Innovation Accelerator, as well as three different business models. Several more business models will develop over the next 12 months.

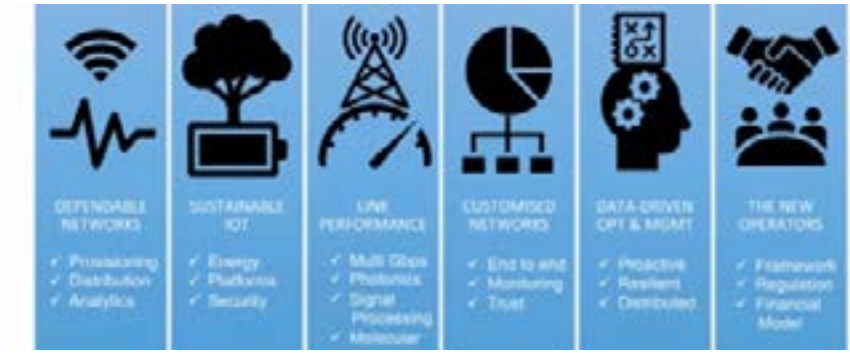
The Future of 5G

Dawn of the New Operator

CONNECT at the Trinity College Dublin compiled the future of telecommunication into six pillars:

- Dependable networks
- sustainable IoT
- link performance
- customized networks
- data-driven optimization & management
- new operators

Future network operators may have to evolve in a very radical way, and that may lead to the rise of a new type of operator, said CONNECT Director Professor Luiz DaSilva. These operators will need to be smaller, more nimble, and operate either alongside or in competition with existing ones.



"What we have to do is understand what the data-driven solutions will be that enable us to design our smart and sustainable cities,"

Alanus von Radecki, Fraunhofer Institute

Putting Data to Work

In our digitally-driven world, data is everywhere you look—but translating that information into something useful can often be a challenge. The first step will be to figure out what data you need to achieve your specific goals.

"What we have to do is understand what the data-driven solutions will be that enable us to design our smart and sustainable cities," said Alanus von Radecki of Fraunhofer Institute, explaining that each layer of a city's infrastructure has its own codes and self-imposed rules to navigate.

The key question to ask yourself before ingesting data is, "why you want it," said Nokia's Global CTO of Smart Cities and Public Sector Richard Cooper.

Closing the Connection Gap

Throughout the 5G CityView Innovation Accelerator, a theme quickly emerged among city representatives—all have discovered or acknowledged a direct link between a lack of connectivity and the poor economic state of its citizens.

Whereas telecoms traditionally invest in neighborhoods that offer the most commercial value, cities are now pushing to extend connectivity into low-income neighborhoods as well.

"Connectivity will not solve digital participation," said Anne McLister of Glasgow, "but it takes away one of the problems which is access. We see that it does support our [plan for] inclusive growth."

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Anne McLister, City of Glasgow

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Technology and Entrepreneurship Center at Harvard

The Technology and Entrepreneurship Center at Harvard (TECH) hosts the 2019 Smart Cities Innovation Accelerator. TECH, part of the Harvard School of Engineering and Applied Sciences, is both a real and virtual space for students, faculty, alumni, and industry leaders to learn together, collaborate, and innovate. TECH enables this holistic exploration by sponsoring and supporting opportunities for the innovation community to gather and exchange knowledge via courses, study groups, mentorship relationships, innovation programs and special events. Find more information at **www.tech.seas.harvard.edu**

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